

## GEAR AND SHAFT ARRANGEMENT FOR AN IMAGE FORMING DEVICE

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### Background

Gear units having a shaft and attached gear are used in countless devices. Because of their high usage, manufacturers look for low cost methods of producing the gear units. However, it is difficult to produce a gear unit at a low cost that has high motion quality. Poor motion quality often causes the shaft to “wobble” on the shaft during rotation.

Many of the existing gear units experience poor motion quality caused by uniformity problems in one or both of the shaft and gear. For gears, the interior opening that receives the shaft is often the cause of the problems. Poorly constructed interior openings cause the shaft to not seat properly on the shaft. This is especially prevalent in embodiments having interior openings that become non-uniform during use.

Another problem occurs in connecting the gear to the shaft. One common manner of attachment is referred to as a press fit. However, when the stresses of the press fit load are applied, the gear deflects unevenly, especially when the interior opening is non-uniform. Another concern is the press fit assembly of the gear upon the shaft. Due to manufacturing variation as well as creep, press fits have been found to be unreliable in high volume manufacturing environments.

Further, the gear unit should be constructed in an economical manner. Gear units should not be outlandishly priced that it is not practical for use within the device. Improvements to the connection between the gear and shaft should add to the performance of the device, but not at a price that will prevent its use.

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## Summary

The present invention is directed to a gear unit comprising a gear and a shaft. The gear provides a solid axial and rotational attachment to the shaft.

In one embodiment, the gear device comprises the shaft having a first  
5 section offset from a second section, with the second section having an engagement member. The gear also has a first section offset from a second section, with exterior teeth positioned on the first section and an engagement member on the second section. The first sections and second sections are aligned together when the gear is operatively engaged with the shaft. Also, the  
10 engagement members are both in the second sections, which is offset from the exterior teeth which are in the first section.

In another embodiment, the gear device includes a first section positioned within a first axial plane with an interior member mounted within an inner diameter of an exterior member. The exterior member further includes  
15 outwardly-extending teeth in the first section. A second section is positioned within a second axial plane that is offset from the first axial plane. The second section has a first engagement section at a distal end of the interior member that engages a second engagement section of the exterior member.

One method of using the gear unit comprises positioning the gear over the  
20 shaft with the first axial section of the gear aligning with the first axial section of the shaft, and the second axial section of the gear aligning with the second axial section of the shaft. The next step is rotating the gear relative to the shaft with an outer diameter of the first axial section of the shaft moving within an inner diameter of the gear. Rotation further causes a pair of extensions on an inner  
25 side wall of the second axial section of the gear to mate within a gap at the second axial section of the shaft. Further, teeth positioned on an exterior surface of the first axial section of the gear are engaged with a second gear within the image forming device.

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### Brief Description of the Drawings

Figure 1 is an exploded partial perspective view of a gear and shaft according to one embodiment of the present invention;

Figure 2 is a partial perspective view of the gear in a disengaged orientation on the shaft according to one embodiment of the present invention;

Figure 3 is a partial perspective view of the gear in an engaged orientation on the shaft according to one embodiment of the present invention;

Figure 4 is a cross-sectional view cut along line 4—4 of Figure 3 of the gear and shaft in the engaged orientation according to one embodiment of the present invention;

Figure 5 is schematic view of an image forming device according to one embodiment of the present invention;

Figure 6 is partial perspective view of drive mechanisms within the main body of the image forming device according to one embodiment of the present invention;

Figure 7 is a perspective view of an image forming unit according to one embodiment of the present invention.

Figure 8 is a perspective view of drive mechanisms extending from the main body according to one embodiment of the present invention; and

Figure 9 is a perspective view of an image forming unit according to one embodiment of the present invention.

### Detailed Description

The present invention is directed to a gear unit, generally illustrated as 10 in Figure 1, comprising a shaft 20 and a gear 30. The shaft 20 includes a first axial section 40a, offset from a second axial section 50a. Likewise, the gear includes a first axial section 40b, offset from second axial section 50b. The first axial sections 40a, 40b and the second axial sections 50a, 50b align when the gear 30 is mounted on the shaft 20. The gear 30 includes teeth 31 on the first axial section 40b. The second axial sections 50a, 50b include features that

contact together to engage the shaft 20 and gear 30. The teeth 31 are positioned within a first axial plane, and the engagement features are located within a second axial plane.

Figure 1 illustrates an exploded view of the gear unit 10. The shaft 20 has  
5 an elongated shape with the first axial section 40a adjacent to, co-axial with, and inward from the distally-positioned second axial section 50a. The first axial section 40a is substantially cylindrical with a round cross-sectional shape. In one embodiment, the surface of the first axial section 40a is smooth.

The second axial section 50a is shaped to engage with the gear 30 as will  
10 be explained in detail below. In the embodiment of Figure 1, second axial section 50a includes a neck 24 and a head 23. The neck 24 is shorter than the head 23 when measured along the first axis A. The width of the neck 24 may be less than or equal to the head 23 when measured along a second axis that is perpendicular to the first axis A. One or more gaps 60 are formed adjacent to the  
15 neck 24 between an inner edge of the head 23 and an outer edge of first axial section 40a. One or more contact surfaces 25 extend along the head 23 for contacting the gear 30. In one embodiment, the head 23 is substantially rectangular having two contact surfaces 25 (i.e., as illustrated in Figure 1, an upper contact surface and a lower contact surface). Other embodiments may  
20 also be used, including a D-shaped head having a single contact surface 25.

The gear 30 includes a first axial section 40b that is coaxial with a second axial section 50b. The first axial section 40b includes a plurality of outwardly extending teeth 31. The number, size, shape, and orientation of the teeth 31 may vary depending upon the application. An interior section 32 of the first axial  
25 section 40b has a shape that conforms to the first axial section 40a. In one embodiment, the interior section 32 has a rounded shape with a substantially smooth surface.

The second axial section 50b includes a pair of hubs 33 that extend outward from a sidewall 38. Each of the hubs 33 includes a contact surface 35  
30 that contact surfaces 25 of the shaft 20. The hubs 33 and contact surface 35 may have a variety of shapes. The hubs are spaced to be about 180° apart. A

distance between the outer edges of the hubs 33 is less than the length of the head 23.

An extension 36 extends outward from the sidewall 38. In one embodiment, extensions 36 are aligned at about a 90° angle to the sidewall 38.

5 Extension 36 has a width less than or equal to the width of the gap 60. In one embodiment, extension 36 has a ramped shape with an increasing size that is at a maximum at the hub 33. In one embodiment, two extensions 36 are positioned on the interior surface 38 and each lead into one of the hubs 33. One or more apertures 39 may be positioned on the hub 33 to prevent shrinkage when the  
10 gear 30 is created during a molding process.

Figure 2 illustrates a partial side view of the shaft 20. Gaps 60 are positioned adjacent to the neck 24 on an inner edge of the head 23. Figure 3 illustrates a cross-sectional view of the gear 30. The extension 36 has a ramped shape that extends into the hub 33. In this embodiment, teeth 31 have a curved  
15 configuration with the cut sections on the upper and lower edges being offset when illustrated in cross-section.

Figure 4 illustrates the gear 30 positioned on the shaft 20 in a disengaged orientation. The gear 30 is positioned onto the shaft 20 with both the first axial sections 40a, 40b, and the second axial sections 50a, 50b being aligned. In this  
20 disengaged orientation, the head 23 and neck 24 are aligned adjacent to the hubs 33. The one or more extensions 36 are spaced apart from the one or more gaps 60 and the gear 30 may be removed axially from the shaft 20.

Figure 5 illustrates the gear 30 and shaft 20 in an engaged orientation. The gear 30 has been rotated relative to the shaft 20 in the working direction  
25 indicated by arrow X with the one or more extensions 36 now positioned within the one or more gaps 60. The contact surfaces 35 on the hubs 33 are in contact with the contact surfaces 25 of the shaft 20. In the engaged orientation, the gear 30 cannot be axially removed from the shaft 20 because the one or more extensions 36 are held within the one or more gaps 60.

30 Figure 6 illustrates a cross-sectional view of the gear unit 10 in the engaged orientation. The shaft first axial sections 40a is longer than the gear

first axial section 40b. The inner edge of the hub 33 contacts the distal edge of the first axial section 40a to control the position of the gear 30 on the shaft 20. In one embodiment, an inner edge of the extension 35 is aligned with the inner edge of the hub 33 and also contacts the distal edge of the first axial section 40a when the gear 30 is mounted on the shaft 20. The second axial section 50a is engaged with the second axial section 50b by the extensions 36 that fit within the gaps 60. The extensions 36 contact the head 25 and prevent the gear 30 from being axially removed from the shaft 20. The width of the gear first axial section 40b is illustrated as N, and the width of the gear second axial sections 50b is illustrated as M. In one embodiment, the width N is about twice that of width M.

The inside diameter of the first axial section 40a of the shaft 20 is sized to fit within the first axial section 40b of the gear 30. The relative sizes provide for the gear 30 to rotate about the shaft 20 when moving from the disengaged to the engaged orientation. In one embodiment, the outer diameter of the shaft first axial section 40a is slightly larger than the inner diameter of the gear first axial section 40b. Gear 30 plastically deforms when the gear is mounted to the shaft 20 for a locational interference fit to physically retain the gear 30 on the shaft 20. The amount of plastic deformation is minimum with no print defects being caused by inaccurate gear movement. In one embodiment, the smallest outside diameter of the first axial section 40a and the largest inside diameter of the first axial section 40b of the gear 30 fit line-to-line. This arrangement prevents the gear 30 from wobbling relative to the shaft 20, while also reducing the stresses on the gear 30 when the largest outside diameter of the first axial section 40a and the smallest inner diameter of the first axial section 40b are fitted.

As illustrated in Figure 6, a first axial plane includes the first axial sections 40a, 40b. The axial section 40b may support and contact the axial section 40a, but there is no other engagement between the shaft 20 and gear 30. The teeth 31 are positioned within this first axial plane. A second axial plane includes the second axial sections 50a, 50b. The gear 30 engages the shaft 20 in this second plane. Distortions in the gear 30 that may result from the engagement with the shaft 20 are minimized in the first axial plane and teeth 31. The minimization of

distortions reduces or eliminates transmission errors between the gear 30 and outside member. Further, the engagement allows for high axial loads between the shaft 20 and gear 30.

Figure 7 illustrates one embodiment of an image forming 100 device in which the gear unit 10 may be used. The image forming device 100 comprises a main body 120 having a media tray 140 with a pick mechanism 160, or a manual input 320, for introducing media sheets into the device 100. The media tray 140 is preferably removable for refilling, and located on a lower section of the device 100.

Media sheets are moved from the input and fed into a primary media path. One or more registration rollers 170 disposed along the media path aligns the print media and precisely controls its further movement along the media path. A media transport belt 200 forms a section of the media path for moving the media sheets past a plurality of image forming units 110. Color printers typically include four image forming units 110 for printing with cyan, magenta, yellow, and black toner to produce a four-color image on the media sheet.

An imaging device 220 forms an electrical charge on a photoconductive member 92 within the image forming units 110 as part of the image formation process. Toner within the image forming units 110 is transferred from a developer member 45 to the charged areas of the photoconductive member 92. The toner is then transferred to the media sheets as they move along the media transport belt 200. The media sheet with loose toner is then moved through a fuser 240 that adheres the toner to the media sheet. Exit rollers 260 rotate in a forward direction to move the media sheet to an output tray 280, or rollers 260 rotate in a reverse direction to move the media sheet to a duplex path 300. The duplex path 300 directs the inverted media sheet back through the image formation process for forming an image on a second side of the media sheet.

The image forming units 110 are removably mounted within the main body 120. The units 110 may include consumable elements, such as toner, developer members 45, photoconductive members 92, and the like, that have a limited lifetime relative to the components within the main body 120. When the

consumable elements have been exhausted from one of the individual units 110, the unit 110 is removed from the main body 120 and replaced with a new unit. A one-piece image forming unit is available in Model No. C750 available from Lexmark International, Inc. of Lexington Kentucky. A two-piece image forming unit is disclosed in U.S. Patent Application Serial No. \_\_\_\_/\_\_\_\_\_  
 5 entitled "Image Forming Apparatus Having a Door Assembly and Method of Use" (Attorney Docket No. 4670-261) and incorporated by reference in its entirety.

The image formation process requires precise timing between the developer member 45, photoconductive member 92, and media sheet moving  
 10 along the transport belt 200. A controller 136 within the main body 120 oversees the image formation process and ensures the proper timing for acceptable image formation. The rotation of the developer member 45 and the photoconductive member 92 within the image forming units 110 is controlled by drive mechanisms 300 within the main body 120. Figure 8 illustrates the drive mechanisms 300  
 15 extending outward from the main body 120 that mates with the image forming units 110. Figure 8 illustrates four separate drive mechanisms 300 that each engages one of the image forming units 110. The exact timing of the image formation process is controlled by accurate rotation of the drive mechanisms 300 which in turn are forwarded to the image forming units 110.

Figure 9 illustrates the exterior of an image forming unit 110. The unit 110  
 20 includes a gear train 400 including the gear unit 10 which is mounted on the distal end of the developer member 45. When the unit 110 is mounted within the main body 120, the gear train 400 is operatively connected to one of the drive mechanisms 300. Rotation from the drive mechanism 300 is transferred to the  
 25 gear train 400 and gear unit 10 which in turn causes the developer member 45 to precisely rotate. In the specific embodiment illustrated in Figures 8 and 9, drive mechanism 300 includes a connection 302 that mounts within a gear 402. Gear 402 includes exterior teeth that engage the teeth 31 of the gear unit 10. The gear train 400 may also include additional gears 403 for rotating other  
 30 components, such as the photoconductive member 92, agitating members that move the toner, etc. In the embodiment illustrated, shaft 20 of the gear unit 10 is



operatively connected to the developer member 45. The gear unit 10 may also be attached to other components within the image forming units 110, or within the main body 120.

5       The term “image forming device” and the like is used generally herein as a device that produces images on a media sheet. Examples include but are not limited to a laser printer, ink-jet printer, fax machine, copier, and a multi-functional machine. One example of an image forming device is Model No. C750 available from Lexmark International, Inc. of Lexington Kentucky.

10       The present invention may be carried out in other specific ways than those herein set forth without departing from the scope and essential characteristics of the invention. In one embodiment, the gear 30 is constructed of plastic, and the shaft 20 is constructed of metal. In one embodiment, the media path comprises nip rollers that move the media sheets past each of the image forming units 110. In one embodiment, the shaft first axial section 40a is at least twice as long as  
15       the shaft second axial section 50a, and the gear first axial section 40b is at least twice as long as the gear second axial section 50b. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

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